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Description

The present invention relates to the art of detecting the position and/or the speed of a moving object and it is particularly concerned with an apparatus designed for the said purpose and defined in the preamble of the appended claim 1.

An apparatus of the said kind is known from EP-A-0 145 935. There it is disclosed an apparatus in which for detecting a speed and/or a position of a moving body, sine wave original signals generated by an encoder mounted on the said body are compared with a sawtooth carrier wave signal for a pulse width modulation. A microcomputer is used for effecting an analog-to-digital conversion of the sinusoidal wave signal performing a first algorithm having a value of the pulse width measured for every carrier wave period applied thereto. Further, after an operation mode is determined on the basis of the states of a first phase signal and a second phase signal the first algorithm is replaced to another one of a predetermined series of algorithms to determine a fine position using further pulse width values.

Further, in EP-A-0 162 268 an apparatus is disclosed in which the detection of a coarse position is effected by using the zero-crossings of an encoder original signal to generate a first signal having a period equal to 1/4 the period of the encoder pulses and counting pulses in the said first signal in an up/down counter. The detection of a fine position is effected by sampling and holding a first phase signal and a second phase signal at every sampling time point. For each sampling a sawtooth wave pulse is generated and time widths are measured to determine a fine position using predetermined algorithms. Further, while a position of a moving body is detected using the coarse and fine position signals and another predetermined algorithm, a speed of the body is determined. In summary, a coarse position of the body is determined from zero-crossing of a sinusoidal or sine wave signal, a fine position is determined from an analog value of the sinusoidal or sine wave signal and the position of the body is determined from the coarse and fine positions in combination. A speed of the body is determined from a difference between the positions of the body at each sampling time point.

Moreover, in JP 81 185 A an apparatus is disclosed in which an encoder detects the rotational angle of a rotating body or the position of a moving body magnetically or optically and generates pulse signals the rise or fall edges of which are counted to obtain the position or speed of said rotating or moving body. The said apparatus includes a high-resolution encoder used at low speeds and a lower-resolution encoder used a higher speeds. Data on the actual speed are obtained by counting pulses produced for a predetermined sample time or a predetermined number (two or more) of inter-pulse time intervals.

To further illustrate the problems involved, a specific speed detection process will now be described with reference to Fig. 4 in which reference character P denotes a train of pulses obtained from the encoder, and Ts is a sample time which is about 0.5 msec in the particular example. A high accuracy value indicative of the detected speed is obtained by detecting the number of pulses P_n produced for a sample time T_s, and the interval T_d between the pulses P_n, and performing the following division:

$$N = K_1 \frac{P_n}{T_d} \quad \cdots\cdots \quad (1)$$

When the rotating body or moving body falls in a low or extremely low speed region, no pulses P_n are produced in a predetermined sample time to thereby render the detection of the speed uncertain.

This process is hereinafter referred to as a pulse detecting system. According to this system, it it impossible to detect a position falling between adjacent pulses even if the number of pulses per rotation and resolution are increased using excellent manufacturing techniques.

For example, a direct drive motor which drives a load using no gears can rotate at an extremely low speed lower than one rotation per minute. According to the pulse detection system, there are no plurality of pulses in a sample time, or there are only a very few pulses, if any, and therefore, stabilized speed control cannot be expected. It is obvious that the use of long sample time increases the number of pulses to be detected in the sample time to thereby enable stabilized control, of course. However, the responsiveness to control is lowered.

The original signal from the encoder generally takes the form of a sine wave signal or a signal similar thereto. In a sine wave signal detection system which uses the analog value of the original signal as it is as a position signal, a superhigh resolution of more than a million pulse per rotation is obtained to thereby enable substantially stepless position detection and to bring about a shortened sample time and rapid

control.

On the other hand, since the analog signal is used, the encoder and the controller cannot be connected in an isolated manner through a photocoupler for a signal transmission. Therefore, the controller is likely to be influenced by noise to thereby render it impossible to provide a long transmission distance.

It is an object of the present invention to provide an apparatus which is capable of detecting also extremely low speed rotations or movements of a rotating or moving object without any pulsation while moreover improving the frequency response characteristics to provide rapid control of the rotating or moving body, insulating the transmission path between the encoder and the controller for transmitting purposes and increasing the resistance of the controller against noise and the tolerable length of the signal transmission path.

The said object is achieved by structuring the detecting apparatus as defined in the appended claim 1; advantageous further developments of the invention are defined in the dependent claims.

According to one of the main features of the present invention, for the detection of the position or speed of a moving body, when the moving speed of said body is low, an output of a sine wave encoder is subjected to a pulse width modulation (PWM) for transmission through a transmission channel to a controller, and the thus modulated signal is re-converted at the controller to recover a sine wave in which a rectangular wave signal is reproduced from zero-crossing of the recovered sine wave signal and a coarse position of the body is determined from the reproduced rectangular wave signal.

Additionally, an analog signal of the sine wave is used to detect a fine position of the body. For final detection of the position or speed of the moving body the informations on the coarse and fine position of the body are used at the speed controller (high resolution system).

When the moving speed of the body is high, a rectangular wave pulse signal is produced from zero-crossing of the output of the sine wave encoder which is used as a coarse position signal for detection of the position or speed of the moving body (pulse system).

Moreover, the present invention is particularly featured in that switching is effected such that the above-mentioned high resolution system using fine and coarse position signals in combination is adopted when the speed of the moving body is low and that the above-mentioned pulse system using the rectangular wave pulse signal is used when the speed of the moving body is high.

Generally, in performing the present invention pulse signals representative of the output of a position detector generated in an encoder-side block are transmitted to a controller-side block which receives said pulse signals and converts them to analog sine wave signals. When the speed of the moving and/or rotating body is low, the re-converted analog signals are used for a fine position detection. When the speed of the moving and/or rotating body is high, use is made of the number of pulses appearing within a sampling time and the interval between pulses, without resorting to the above-mentioned fine position detection technique. More specifically, in the present invention, when the speed controller indicates that the moving and/or rotating speed is low, both fine and coarse positions are detected for a position/speed detection, while when the speed controller indicates that the moving/rotating speed is high, the number of pulses appearing within a sampling time and the pulse interval are measured for a position/speed detection. In the latter case, i.e. when the speed controller indicates that the moving/rotating speed is high, the above-mentioned pulse signals transmitted by the encoder-side block and received in the controller-side block are used to generate rectangular wave pulse reproduction signals for the frequency from the output of the position detector being relatively low and rectangular wave original signals from the original pulse producing circuits transmitted by the encoder-side block and received in the controller-side block are used to reproduce the original wave signals for the frequency from the output of the position detector being relatively high.

An apparatus according to the present invention provides optimal control from high speed to extremely low speed at which speed detection is effected with superhigh resolution using analog values, so that uneven rotation is prevented. The transmission through the photocoupler serves to shut off noise from the position detector (encoder) to thereby prevent the malfunction of the controller.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a position and speed detector according to one embodiment of the present invention.

FIG. 2 shows another embodiment.

FIG. 3 shows a modification of the embodiment of FIG. 2.

FIG. 4 is a timing chart in the use of a pulse detection system.

FIG. 5 is a block diagram of a sine wave signal detection system.

FIG. 6 is a timing chart in the use of the sine wave signal detection system.

FIG. 7 is a timing chart in the use of PWM transmission at low speed.

FIG. 8 is a timing chart in pulse transmission at high speed.

FIG. 9 is an illustration involving respective waveform switching points.

FIG. 10 shows a switching circuit to prevent hazards.

FIG. 11 is a timing chart for switching between a sine wave pulse and an insulating pulse when the speed changes from low to high.

FIG. 12 is a chart indicative of the timing for switching between a sine wave pulse and an insulating pulse when the speed changes from high to low.

FIG. 13 shows a further embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A specific embodiment of the present invention will now be described with reference to the drawings. First, a sine wave signal detection system will be outlined with reference to FIGs. 5 and 6. A speed detector is a sine wave encoder. This is referred to as a sine wave signal detection system. Position detection is effected by using a coarse position detecting circuit 19 and a fine position detection circuit 14. In the detection of a coarse position, reproduced sine wave output A6 and B6 are shaped to pulses A7 and B7, which are converted to count signals A_c at rise and fall edges (zero-crossing points) of each of the signals A7 and B7 and the count signals are detected by an up/down (U/D) counter 24. The detection of the coarse position is effected by using the count in the U/D counter 24 latched in a latch circuit 25 at sample times of T_s. For example, a value on a coarse position $\theta_{R(n-1)}$ latched at a time $t_{(n-1)}$ or a point ① in FIG. 6 is held to the next sample point ② or a time t_n. The coarse position value θ_{Rn} is latched at a time t_n or point ②.

The value θ_F of the fine position detection 14 will be detected as follows. The reproduced sine wave signals A6 and B6 in A- and B-phases are, respectively, held at the sample point 1 by a sample and hold circuit 26 to provide analog values $e_{A(n-1)}$ and $e_{B(n-1)}$. These values are converted by a A/D converter 27 to digital values $E_{A(n-1)}$ and $E_{B(n-1)}$. A value θ_F is calculated by a position and speed measuring circuit 20 as follows:

$$\theta_{F(n-1)} = K_1 \tan^{-1}(E_{A(n-1)}/E_{B(n-1)}) \qquad (2)$$

The calculation of the equation (2) may be performed by software in a microcomputer, for example. The microcomputer calculates the following equation (3):

$$E_{A(n-1)}/E_{B(n-1)} \qquad (3)$$

On the other hand, data on tan θ_F is stored beforehand in a table in ROM. The fine position is detected by using an address $\theta_{F(n-1)}$ in the ROM where the value of the equation (3) coincides with data on tan θ_F. The number of data segments on tan θ_F at that time is the divisor between adjacent count signals A_c and represents the resolution on the position. A position θ is calculated from a coarse position θ_R and a fine position θ_F as follows:

$$\theta = \theta_R + \theta_F \qquad (4)$$

If the fine position θ_F is represented with 8 bits and the coarse position θ_R is represented with the subsequent bits, data on the coarse and fine positions constitutes a series of data. Since the position is detected at constant sample intervals, the speed ω is detected as the differential between the positions:

$$\omega = d\theta/dt = C\ (\text{n-th position data } \theta_n \text{ -(n-1)th position } \theta_{(n-1)}) \qquad (5)$$

A specific circuit diagram and a control system and method according to the present invention will now be described with reference to the drawings. First, one embodiment for detection of a position according to the present invention will now be described with reference to the drawings concerned. FIG. 1 is a circuit diagram of one embodiment according to the present invention. FIG. 7 is a timing chart for the embodiment, but a timing chart for B-phase is omitted. Reference numeral 3 denotes a position detector which generates sine wave or triangular wave analog signals A and B 90° out of phase and corresponding to the speed of a rotating or moving body (not shown); 6 and 7, pulse width modulation pulse generators which compare a corresponding analog output and a triangular or saw-tooth wave to output pulse outputs indicated by A4 and B4, respectively; 12 and 13, analog converters which convert PWM outputs A4 and B4 to corresponding analog sine wave or triangular wave signals indicated by A6 and B6, respectively; and 15 and 16, pulse

shaping circuits which form square pulses from the reproduced analog outputs A6 and B6 indicated by A8 and B8, respectively; 19, a coarse position detector which counts edges of the outputs A8 and B8 from the pulse shaping circuits 15 and 16 using a U/D counter; 14, a fine position detector which divides by n an inter-coarse position pulse interval from the reproduced analog outputs A6 and B6; 20, a position and speed detector of a sine wave signal detection system and including a microcomputer which calculates the equations (2) - (5); and 23, a speed controller which calculates the error between a speed command (not shown) and the calculated speed and performs a proportional and integral operation on the error.

FIG. 2 is a block diagram of a further embodiment of the present invention. FIG. 7 is a timing chart for the operation of the particular embodiment performed at low speed and FIG. 8 is a timing chart for the operation of the particular embodiment performed at high speed. A timing chart for B-phase is omitted. The position and speed of the rotating or moving body at low speed can be detected using the system mentioned with reference to FIG. 1. As shown in FIG. 7, when a reproduced sine wave A6 is generated from the PWM output A4, a delay will occur due to the presence of the analog converter 12. The transfer function of the analog converter, represented by G_A, is given by the following first-order lag:

$$G_A = 1/(1 + T_A s) \quad (6)$$

where T_A is a delay time constant and s is a complex variable. Thus, as shown in FIG. 7, the reproduced sine wave A6 is delayed by θ_a in phase from the original signal. When shaped pulses A7 and B7 are formed from the reproduced sine waves in the shaping circuit 15 and 16, the shaped pulses are delayed by θ_h due to the hysteresis characteristics of the shaping circuits 15 and 16, for example, as shown by A7 in FIG. 7. If the rotating or moving body shifts to high speed region under such condition, the delay of the shaped pulses increases to thereby render difficult the correct detection of position and speed.

As shown in FIGs. 2 and 8, signals A31 and B31 little in delay compared to the position detector outputs A1 and B1 are generated by original pulse circuits 61 and 71 to detect the position and speed of the rotating or moving body. The PWM pulses A3 and B3 and original pulses A31 and B31 are generated simultaneously from the outputs A1 and B1 from the position detector 3. The frequency is detected from the output A1 of the position detector 3 using a frequency detector 50 to select the contacts of the first switches 5A and 5B. The contacts a of the switches are selected at low speed such that the PWM pulse circuits 6 and 7 are selected and the contact b is selected at high speed such that the original pulse circuits are selected. The contacts a of the second switches 17 and 18 are selected such that the pulse shaping circuits 15 and 16 are selected at low speed while the contacts b are selected at high speed such that original pulse signals with a little delay are selected. The position and speed detector 21 of a pulse system shapes pulses using the rise and fall edges of square pulses A8 and B8 and detects the position and speed in accordance with the equation (1). In the third switch 22, the contact a is selected to select the position and speed detector 20 of a sine wave system or detection of low speed, and the contact b is selected to select the position and speed detector 21 of a pulse system or the detection of high speed. The speed controller 23 provides speed control using a signal from the position and speed detector and generates signals C6 and C7 to select the contacts of the second switches 17, 18 and the third switch 22.

FIG. 3 shows a modification of the further embodiment. The same reference numeral is used in FIGs. 1, 2 and 3 throughout. The operation of the apparatus at low speed will be illustrated with reference to FIGs. 3 and 7. Reference numerals 1 and 2 denote encoder-side and control circuit-side block diagrams respectively. At low speed, a triangular signal C3 is generated from a carrier wave generator 4, and the contact a of the first switch 5 is selected to output C5. The PWM pulse forming circuits 6 and 7 compares the outputs A1 and B1 from the sine wave generator 3 and the triangular wave C5 to generate PWM outputs A2 and B2. The PWM outputs A2 and B2 are amplified by the drivers 8 and 9 for long-distance and the outputs A3 and B3 of the drivers are transmitted to the control circuit side 2. In the control circuit side 2, the signals A3 and B3 are received by insulating elements 10 and 11 such as a photocoupler or a pulse transformer, which elements 10 and 11 then output signals A4 and B4, respectively. The signals A4 and B4 are converted by the analog converter 12 and 13 to carriers A5 and B5 of bipolarity, and the resulting signals are supplied as reproduced sine wave signals A6 and B6 via corresponding first-order lag filters (not shown).

The contact b of the first switch 5 is selected at high speed such that the first switch 5 selects a zero voltage C4. At this time, as shown in FIG. 8, the PWM pulse forming circuits 6 and 7 compare the outputs A1 and B1 from the sine wave generator with the zero voltage to provide original square pulses A2 and B2 which are then supplied to the drivers 8 and 9 for long-distance transmission and the outputs A31 and B31 from the drivers are then supplied to the control circuit side 2. In the control circuit side 2, the insulating elements 10 and 11 such as a photocoupler or a pulse transformer receive the signals A31 and B31 and output signals A4 and B4, respectively. The second switches 17 and 18 select their contacts b and hence

the signals A4 and B4 and outputs the signals A8 and B8, respectively. The position detector 21 of pulse system receive the signals A8 and B8 and detects the position and speed of the rotating or moving body in accordance with the equation (1), as mentioned above. The third switch 22 selects the contact b to supply the signals from the position and speed detector of pulse system 21 to the speed controller 23, which performs a calculating operation for speed control and generates control signals C7 and C6 for the second and the third switches.

The control signal for the first switch will be described using the block diagram of FIG. 3 and the control diagram of FIG. 9. The output signal A1 from the sine wave generator 3 is delivered to the F/V converter 28 which outputs a signal C1 depending on frequency. The hysteresis comparator 30 generates a signal C2 from the output C1 from the converter 28 and the output from the voltage comparator 29. The signal C2 changes from high to low at a point of f_3 when the frequency of the position detector increases. The output C2 from the comparator 30 changes from low to high at a point of f_2 when the frequency f decreases. At this time, $f_3 > f_2$. The first switch 5 selects its contact a when the hysteresis comparator 30 generates high output, and outputs as C5 a triangular carrier C3. When the comparator 30 output is low, the switch 5 selects its contact b to output the zero voltage C4. The speed controller 23 calculates the frequency of the position detector 3. When the frequency $f < f_1$, the position and speed are calculated according to the sine wave system to select the pulse system detector in a range of $f > f_1$.

When the speed of the rotating or moving body increases, the original pulses A4 and B4 are selected when the position detector frequency $f > f_4$ to effect position and speed detection in the pulse detection system. In a frequency range of $f_1 \leq f \leq f_4$, shaped pulses A7 and B7 are selected to effect the position and speed detection in the pulse detection system. While the interval between f_2 and f_3 is determined by the characteristic of the hysteresis comparator, the interval between f_2 and f_1, and the interval between f_3 and f_4 are required to be larger than a range in which the rotating or moving body is subjected to maximum acceleration or maximum deceleration in a single sample time.

In FIG. 9, an original pulse and a shaped pulse deviate in phase when switching is made between the shaped pulse region and the original pulse region or vice versa. While the original pulse deviates slightly in phase from the sine wave original signal, the shaped pulse is necessarily delayed by a delay θ_a produced by the corresponding one of the analog converter 12 and 13 and by a hysteresis delay θ_h produced by the corresponding one of the pulse shaping circuits 15 and 16. While both the delay times are constant, the phase difference increases as the speed increases. The switching point f_4 occurs at any time, so that a switching hazard occurs at that time to thereby cause an error in the detection of the position and speed.

FIG. 10 illustrates the circuit of the switches 17 and 18 which cause no errors. FIG. 11 is a timing chart illustrating the situation in which switching is made from high speed to low speed.

FIG. 12 is a timing chart showing the situation in which switching is made from low speed to high speed. The reference characters used in FIGs. 11 and 12 are the same as those described with reference to FIG. 8.

In FIG. 11, the switches 17 and 18 select the original pulses A4 and B4 and output A8 and B8 in the high-speed region. In FIG. 11, assume that a signal C7 from the speed controller 23 to switch from the high speed region to the low speed changes low to high. For example, if the signal C7 changes in the phase delay region, the A8 signal, which has already risen high under the influence of the A4 "O" signal, employs the low A7 " x " signal in response to the signal C7 to thereby cause a hazard as shown by the broken lines. In order to prevent the hazard, the actual switching timing is set at a rise edge of a shaped pulse like the signal C8 after the receipt of the switching signal C7 to switch from the high region to the low region at a point of f_4. The embodiment to achieve this object is illustrated in FIG. 10. D-type positive edge flip-flops 31 and 32 are used for switching purposes. Assume that the C7 signal is inputted to a data terminal DA of the flip-flop 31 in the A-phase. Also assume that the transmission signal CKA for data DA is the A7 signal. The output $\widetilde{Q}A$ is applied to one input of an AND gate 33, and QA to one input of an AND gate 34. An insulating element output pulse A4 is applied to the other input of the AND gate 33 and a sine wave pulse A7 is applied to the other input of the AND gate 34. The $\widetilde{Q}A$ output signal includes the inverse of the QA signal. The outputs from the AND gates 33 and 34 are inputted to an OR gate 35 which outputs a signal A8. A timing chart for B-phase is similar to that for A-phase, and omitted.

Assume in FIG. 12 that the signal C7 from the speed controller 23 to switch from the low speed region to high speed region changes from high to low. If the signal C7 changes in the phase delay region, the A8 signal changes high earlier by θ_i, but the sine wave pulse A7 is replaced with the insulating element output pulse A4 by the C8 signal in order to prevent a hazard due to switching from high speed to low speed.

In FIGs. 1 and 2, the outputs A1 and B1 from the position detector 3 may be converted by F/V converters to pulse signals, which may be then transmitted, and reproduced by the V/F converter to analog signals for position and speed detection.

FIG. 13 shows another embodiment viewed from the encoder side. The explanation of reference characters used in the timing charts of FIGs. 7 and 8 are the same as those in Fig. 13. The position detector 3 outputs analog signals A1 and B1 in accordance with the movement of the rotating or moving body. PWM pulse forming circuits 6 and 7 compare the analog signals A1 and B1 with a triangular wave or a saw-tooth wave to output signals A3 and B3, respectively. The original pulse circuits 61 and 71 compare the analog signals A1 and B1 with a zero voltage to output square signals A31 and B31, respectively. The encoder is characterized by outputting these signals A1, B1, A3, B3, A31 and B31.

According to the arrangement of the above embodiments, the encoder and the controller are electrically isolated by transmitting a sine wave signal in the form of a PWM signal. This improves the resistance of the controller side to noise and greatly increases the transmission distance between the encoder and controller. The controller side converts the PWM signal to an analog sine wave signal to employ the position and speed detection in a sine wave system to achieve speed control even to an extremely low speed.

In order to avoid a disturbance in the square pulse from the encoder due to time lag provided by the analog converter in the high speed region, a pulse detection system which detects the speed from the number and interval of square original pulses, not delayed, is employed to thereby provide speed control in the speed range of from extremely low speed to high speed.

The encoder side compares a sine wave signal with a triangular signal when the rotating or moving body is at low speed and when a PWM is generated, and compares a sine wave signal with a zero voltage when the rotating or moving body is at high speed to thereby transmit a pulse, which is received with little delay compared to the original sine wave signal by the controller side. Thus, two accurate incremental encoder waveforms 90° out of phase can be obtained even in the high speed region. Continuous switching is possible by providing hysteresis in the selection of one of a triangular wave and a zero voltage when a PWM is generated.

Smooth continuous speed control is achieved by maintaining the relationship $f_1 < f_2 < f_3 < f_4$ where f_1 is the switching point between the sine wave system and pulse detection system, f_2 is the switching point between a triangular wave and a zero voltage when a PWM is generated in deceleration, f_3 is the switching point between a triangular wave and a zero voltage in acceleration, and f_4 is the switching point between a shaped pulse and the original pulse.

In switching between a shaped pulse and the original pulse, a hazard may occur and hence an error may be involved in the detected position value when a switching signal is generated in the phase delay region for both the pulses due to delay of the shaped pulse when switching is made from high speed to low speed. In order to prevent this, the second switch is switched by a rise edge of the shaped pulse after the switching signal is received to thereby effect accurate position detection.

In addition, a pair of photocouplers is disposed in the transmission paths connecting the corresponding PWM pulse forming circuits and the controller side. Therefore, the rotating or moving body can be controlled in a stabilized manner from high speed to low speed, and especially uneven rotation at extremely low speed is eliminated. Further, the frequency characteristic at high speed is improved.

Noise occurring on the side of the position detector (encoder) is completely shut out from the side of the controller, so that a malfunction is reduced. Additionally, since two signals are obtained from a single encoder, the number of components of the position detector is reduced.

Claims

1. A position and/or speed detecting apparatus comprising
   - a position detector (3) for generating analog signals such as sine waves or triangular waves 90° out of phase depending on movement of a moving or rotating body,
   - PWM pulse forming circuits (6, 7) for performing a pulse width modulation by comparing said analog signals with a sawtooth wave signal to generate PWM pulse signals,
   - original pulse producing circuits (61, 71) each for producing an rectangular original wave signal having a phase identical with one of said analog signals,
   - position/speed detecting means for detecting a position and/or speed of said moving or rotating body from said PWM pulse signals derived from said PWM pulse forming circuits (6, 7) or from said rectangular original wave signal derived from said original pulse producing circuit (61, 67),
   - a controller for controlling a position and/or speed of said moving or rotating body in accordance with a position/speed detection signal from said position/speed detecting means and
   - D/A converters (12, 13) for converting said PWM pulse signals back to analog reproduction signals such as sine waves or triangular waves,

   characterised in

that pulse shaping circuits (15, 16) are provided for shaping said analog reproduction signals to rectangular wave pulse reproduction signals,

that a fine position detector (14) is provided for detecting a fine position of said moving or rotating body from analog values of said analog reproduction signals derived from said D/A converters (12, 13),

that a coarse position detector (19) is provided for detecting a coarse position of said moving or rotating body from edges of said rectangular wave pulse reproduction signals from said pulse shaping circuits (15, 16) or from edges of said rectangular wave original signals from said original pulse producing circuits (61, 67),

that said position/speed detecting means include a first position/speed detector (20) of a sine wave system for detecting a position and/or speed of said moving or rotating body from outputs of said fine and coarse position detectors (14, 19) and a second position/speed detector (21) of a pulse system for detecting a position and/or speed of said moving or rotating body from the number of pulses or the interval of the pulses in said rectangular wave reproduction signals (A7, B7) or in said rectangular wave pulse original signals (A4, B4),

that said controller includes a speed controller (23) for selecting an output of said first position/speed detector (20) or an output of said second position/speed detector (21) for thereby performing arithmetic operations for a speed control of said moving or rotating body,

that a frequency detector (50) is provided for detecting a frequency from the output from said position detector (3),

that first switches (5A, 5B) are provided each for selecting one of an output from said PWM pulse forming circuits (6 or 7) and an output from said original pulse producing circuits (61 or 71) concerned,

that second switches (17, 18) are provided each for selecting one of an output from the corresponding pulse shaping circuit (15 or 16) and an output from said original pulse producing circuits (61 or 71) concerned, depending on a value of a speed of said moving or rotating body obtained by said speed controller (23) and

that a third switch (22) is provided for selecting one of the outputs from said first position/speed detector (20) and said second position/speed detector (21) depending on the speed of said moving or rotating body obtained by said speed controller (23).

2. An apparatus according to claim 1, characterised in

that said frequency detector (50) includes

- a frequency-to-voltage converter (28) for generating a voltage output depending on the frequency detected by said position detector (3),
- a voltage reference generator (29),
- a hysteresis comparator (30) for comparing a voltage output of said frequency-to-voltage converter with a voltage from said voltage reference generator,
- a carrier generator (4) for outputting a triangular or sawtooth wave signal and
- a switch (5) for selecting the output from said carrier generator (4) or a zero voltage, depending on the output from said hysteresis comparator (30)

and

that said second switches (17, 18) each are switched when said speed controller (23) detects a predetermined high speed and

said third switch (22) is switched when said speed controller (23) detects a predetermined low speed, the switching of said third switch (22) being effected in a lower speed region than the switching of said second switches (17, 18) and the switching of said first switches (5A, 5B).

3. An apparatus according to claim 1 or 2, characterised in

that said position detector (3), said PWM pulse forming circuits (6, 7), said first switches (5A, 5B) and said frequency detector (50) are included in an encoder-side block (1) while said D/A converters (12, 13), said pulse shaping circuits (15, 16), said coarse and fine position detectors (19, 14), said original pulse producing circuits (61, 67), said second switches (17, 18), said first and second position/speed detectors (20, 21), said third switch (22) and said speed controller (23) are included in a control-side block (2),

that said analog signals from said position detector (3) are converted to digital signals and transmitted to said control-side block (2) by said encoder-side block (1) and

that said control-side block (2) receives and re-converts said digital signals to analog signals for detecting a position and/or speed of said moving or rotating body.

4. An apparatus according to claim 3, characterised in
that said encoder-side block (1) and said control-side block (2) are electrically coupled to each other by galvanically isolating means (10).

5. An apparatus according to claim 4, characterised in
that said galvanically isolating means (10) is a photocoupler or a pulse transformer.

Patentansprüche

1. Positions- und/oder Geschwindigkeitsmeßgerät, umfassend
- einen Positionsdetektor (3) zum Erzeugen von analogen Signalen wie Sinuswellen oder Dreieckwellen, die abhängig von der Bewegung eines sich bewegenden oder rotierenden Körpers 90° phasenversetzt sind,
- Pulsbreitenmodulation (PWM)-Pulsformerschaltungen (6, 7) zum Durchführen einer Pulsbreitenmodulation durch Vergleichen der analogen Signale mit einem Sägezahnwellensignal, um PWM-Pulssignale zu erzeugen,
- Ausgangspuls-Erzeugerschaltungen (61, 71), jeweils zum Erzeugen eines unmodulierten Rechteckwellensignals, das eine mit einer Phase der analogen Signale übereinstimmende Phase hat,
- ein Positions-/Geschwindigkeitsmeßmittel zum Messen einer Position und/oder Geschwindigkeit des sich bewegenden oder rotierenden Körpers anhand der von den PWM-Pulsformerschaltungen (6, 7) abgeleiteten PWM-Pulssignale oder anhand des von der Ausgangspuls-Erzeugerschaltung (61, 71) abgeleiteten unmodulierten Rechteckwellensignals,
- einen Regler zum Regeln einer Position und/oder Geschwindigkeit des sich bewegenden oder rotierenden Körpers abhängig von einem Positions-/Geschwindigkeitsmeßsignals des Positions-/Geschwindigkeitsmeßmittels und
- D/A-Wandler (12, 13) zum Umwandeln des PWM-Pulssignals zurück in analoge Wiedergabesignale wie Sinuswellen oder Dreieckwellen,

dadurch gekennzeichnet,

daß Pulsformerschaltungen (15, 16) vorgesehen sind zum Formen der analogen Wiedergabesignale in Rechteckwellenpuls-Wiedergabesignale,

daß ein Feinpositionsdetektor (14) vorgesehen ist zum feinen Messen einer Position des sich bewegenden oder rotierenden Körpers anhand von Analogwerten des von dem D/A-Wandler (12, 13) abgeleiteten analogen Wiedergabesignals,

daß ein Grobpositionsdetektor (19) vorgesehen ist zum groben Messen einer Position des sich bewegenden oder rotierenden Körpers anhand von Flanken des Rechteckwellenpuls-Wiedergabesignals der Pulsformerschaltungen (15, 16) oder anhand von Flanken der unmodulierten Rechteckwellensignale der Ausgangspuls-Erzeugerschaltungen (61, 71),

daß das Positions-/Geschwindigkeitsmeßmittel einen ersten Positions-/Geschwindigkeitsdetektor (20) eines Sinuswellensystems aufweist zum Messen einer Position und/oder Geschwindigkeit des sich bewegenden oder rotierenden Körpers anhand von Ausgaben des Fein- und des Grobpositionsdetektors (14, 19) sowie einen zweiten Positions-/Geschwindigkeitsdetektors (21) eines Pulssystems zum Messen einer Position und/oder Geschwindigkeit des sich bewegenden oder rotierenden Körpers anhand der Anzahl von Pulsen oder des Intervalls der Pulse in den Rechteckwellen-Wiedergabesignalen (A7, B7) oder in den unmodulierten Rechteckwellenpulssignalen (A4, B4),

daß der Regler einen Geschwindigkeitsregler (23) aufweist zum Auswählen einer Ausgabe des ersten Positions-/Geschwindigkeitsdetektors (20) oder einer Ausgabe des zweiten Positions-/Geschwindigkeitsdetektors (21), um daran Rechenoperationen für eine Geschwindigkeitskontrolle des sich bewegenden oder rotierenden Körpers durchzuführen,

daß ein Frequenzdetektor (50) vorgesehen ist zum Messen einer Frequenz an dem Ausgang des Positionsdetektors (3),

daß erste Schalter (5A, 5B) vorgesehen sind, jeweils zum Auswählen einer Ausgabe der PWM-Pulsformerschaltungen (6 oder 7) und einer Ausgabe der betroffenen Ausgangspuls-Erzeugerschaltungen (61 oder 71),

daß zweite Schalter (17, 18) vorgesehen sind, jeweils zum Auswählen einer Ausgabe der entsprechenden Pulsformerschaltung (15 oder 16) und einer Ausgabe der betroffenen Ausgangspuls-Erzeugerschaltungen (61 oder 71), abhängig von einem von dem Geschwindigkeitsregler (23) erhaltenen Wert einer Geschwindigkeit des sich bewegenden oder rotierenden Körpers

und

daß ein dritter Schalter (22) vorgesehen ist zum Auswählen einer der Ausgaben des ersten Positions-/Geschwindigkeitsdetektors (20) und des zweiten Positions-/Geschwindigkeitsdetektors (21), abhängig von der von dem Geschwindigkeitsregler (23) erhaltenen Geschwindigkeit des sich bewegenden oder rotierenden Körpers.

2. Gerät nach Anspruch 1, dadurch gekennzeichnet
daß der Frequenzdetektor (50) aufweist
- einen Frequenz-Spannungs-Wandler (28) zum Erzeugen einer Spannungsausgabe, abhängig von der von dem Positionsdetektor (3) gemessenen Frequenz,
- einen Spannungsreferenzgenerator (29),
- einen Hysteresekomparator (30) zum Vergleichen einer Spannungsausgabe des Frequenz-Spannungs-Wandlers mit einer Spannung von dem Spannungsreferenzgenerator,
- einen Trägerwellengenerator (4) zur Ausgabe eines dreieckigen oder Sägezahn-Wellensignals und
- einen Schalter (5) zum Auswählen der Ausgabe des Trägerwellengenerators (4) oder einer Nullspannung, abhängig von der Ausgabe des Hysteresekomparators (30)

und
daß die zweiten Schalter (17, 18) jeweils geschaltet werden, wenn der Geschwindigkeitsregler (23) eine vorgegebene hohe Geschwindigkeit mißt
und
der dritte Schalter (22) geschaltet wird, wenn der Geschwindigkeitsregler (23) eine vorgegebene niedrige Geschwindigkeit mißt,
wobei das Schalten des dritten Schalters (22) in einem niedrigeren Geschwindigkeitsbereich durchgeführt wird als das Schalten der zweiten Schalter (17, 18) und das Schalten der ersten Schalter (5A, 5B).

3. Gerät nach Anspruch 1 oder 2, dadurch gekennzeichnet
daß der Positionsdetektor (3), die PWM-Pulsformerschaltungen (6, 7), die ersten Schalter (5A, 5B) und der Frequenzdetektor (50) in einem kodiererseitigen Block (1) enthalten sind, während die D/A-Wandler (12, 13), die Pulsformerschaltungen (15, 16), der Grob- und der Feinpositionsdetektor (19, 14), die Ausgangspuls-Erzeugerschaltungen (61, 71), die zweiten Schalter (17, 18), die ersten und zweiten Positions-/Geschwindigkeitsdetektoren (20, 21), der dritte Schalter (22) und der Geschwindigkeitsregler (23) in einem reglerseitigen Block (2) enthalten sind,
daß die Analogsignale des Positionsdetektors (3) in digitale Signale umgewandelt und von dem kodiererseitigen Block (1) an den reglerseitigen Block (2) übermittelt werden und
daß der reglerseitige Block (2) die digitalen Signale empfängt und sie in analoge Signale zurückwandelt, um die Position und/oder Geschwindigkeit des sich bewegenden oder rotierenden Körpers zu messen.

4. Gerät nach Anspruch 3, dadurch gekennzeichnet
daß der kodiererseitige Block (1) und der reglerseitige Block (2) mittels eines galvanisch isolierenden Mittels (10) elektrisch miteinander gekoppelt sind.

5. Gerät nach Anspruch 4, dadurch gekennzeichnet
daß das galvanisch isolierende Mittel (10) ein optoelektronischer Koppler oder ein Pulsübertrager ist.

Revendications

1. Dispositif de détection de position et/ou de vitesse comprenant
- un détecteur de position (3) servant à produire des signaux analogiques tels que des ondes sinusoïdales ou des ondes triangulaires déphasées de 90° en fonction du déplacement d'un corps mobile ou rotatif,
- des circuits (6, 7) de formation d'impulsions MID pour l'exécution d'une modulation d'impulsions en durée par comparaison desdits signaux analogiques à un signal d'onde en dents de scie pour la production de signaux impulsionnels MID,
- des circuits (61, 71) de production d'impulsions originelles, servant chacun à produire un signal en onde originelle rectangulaire et possédant une phase identique à celle de l'un desdits signaux analogiques,

- des moyens de détection de position/vitesse pour détecter une position et/ou une vitesse dudit corps mobile ou rotatif à partir desdits signaux impulsionnels MID délivrés par lesdits circuits (6, 7) de formation d'impulsions MID ou à partir dudit signal en onde originelle rectangulaire, délivré par ledit circuit (61, 67) de production d'impulsions originelles,
- un dispositif de commande pour commander une position et/ou une vitesse dudit corps mobile ou rotatif en fonction d'un signal de détection de position/vitesse délivré par lesdits moyens de détection de position/vitesse, et
- des convertisseurs numérique/analogique (12, 13) pour convertir de façon inverse lesdits signaux impulsionnels MID en des signaux de reproduction analogiques, tels que des ondes sinusoïdales ou des ondes triangulaires,

caractérisé en ce

qu'il est prévu des circuits de mise en forme d'impulsions (15, 16) pour amener lesdits signaux analogiques de reproduction sous la forme de signaux impulsionnels de reproduction en ondes rectangulaires,

qu'il est prévu un détecteur de position précise (14) pour détecter une position précise dudit corps mobile ou rotatif à partir de valeurs analogiques desdits signaux analogiques d'introduction délivrés par lesdits convertisseurs numérique/analogique (12, 13),

qu'il est prévu un détecteur de position approximative (19) pour détecter une position approximative dudit corps mobile ou rotatif à partir de flancs desdits signaux impulsionnels de reproduction en ondes rectangulaires délivrés par lesdits circuits de mise en forme d'impulsions (15, 16) ou à partir de flancs desdits signaux originels en ondes rectangulaires délivrés par lesdits circuits (61, 67) de production d'impulsions originelles,

que lesdits moyens de détection de position/vitesse comprennent un premier détecteur de position/vitesse (20) d'un système en ondes sinusoïdales pour détecter une position et/ou une vitesse dudit corps mobile ou rotatif à partir de signaux de sortie desdits détecteurs (14, 19) de position précise et de position approximative, et un second détecteur de position/vitesse (21) d'un système à impulsions pour détecter une position et/ou une vitesse dudit corps mobile ou rotatif à partir du nombre d'impulsions ou de l'intervalle des impulsions dans lesdits signaux de reproduction en ondes rectangulaires (A7, B7) ou dans lesdits signaux impulsionnels originels en ondes rectangulaires (A4, B4),

que ledit dispositif de commande comprend un dispositif de commande de vitesse (23) servant à sélectionner un signal de sortie dudit premier détecteur de position/vitesse (20) ou un signal de sortie dudit second détecteur de position/vitesse (21) pour exécuter de ce fait des opérations arithmétiques pour une commande de la vitesse dudit corps mobile ou rotatif,

qu'il est prévu un détecteur de fréquence (50) pour détecter une fréquence à partir du signal de sortie dudit détecteur de position (3),

que des premiers commutateurs (5A, 5B) sont prévus chacun pour la sélection d'un signal de sortie délivré par lesdits circuits de formation d'impulsions MID (6 ou 7) ou d'un signal de sortie délivré par lesdits circuits concernés (61 ou 71) de production d'impulsions originelles,

qu'il est prévu des seconds commutateurs (17, 18) servant chacun à sélectionner un signal de sortie délivré par le circuit correspondant (15 ou 16) de mise en forme d'impulsions ou un signal de sortie délivré par lesdits circuits concernés (61 ou 71) de production d'impulsions originelles, en fonction d'une valeur d'une vitesse dudit corps mobile ou rotatif, délivrée par ledit dispositif (23) de commande de la vitesse, et

qu'il est prévu un troisième commutateur (22) pour sélectionner l'un des signaux de sortie délivrés par ledit premier détecteur de position/vitesse (20) et ledit second détecteur de position/vitesse (21), en fonction de la vitesse dudit corps mobile ou rotatif obtenue par ledit dispositif (23) de commande de la vitesse.

2. Dispositif suivant la revendication 1, caractérisé par le fait que ledit détecteur de fréquence (50) comprend
   - un convertisseur fréquence-tension (28) pour produire une tension de sortie en fonction de la fréquence détectée par ledit détecteur de position (3),
   - un générateur de tension de référence (29),
   - un comparateur à hystérésis (30) pour comparer une tension de sortie dudit convertisseur fréquence-tension à une tension délivrée par ledit générateur de tension de référence,
   - un générateur de porteuse (4) pour délivrer un signal en onde triangulaire ou en dents de scie, et
   - un commutateur (5) pour sélectionner le signal de sortie délivré par ledit générateur de porteuse (4) ou une tension nulle, en fonction du signal de sortie délivré par ledit comparateur à hystérésis

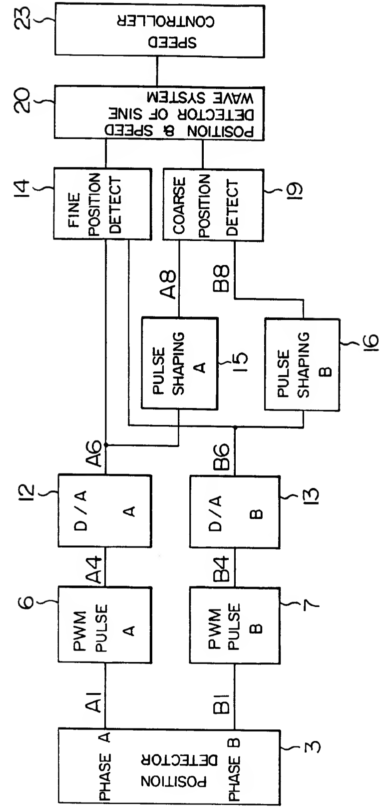
(30), et
- que lesdits seconds commutateurs (17, 18) sont commutés chacun lorsque ledit dispositif (23) de commande de la vitesse détecte une vitesse élevée prédéterminée, et
- que ledit troisième commutateur (22) est commuté lorsque ledit dispositif (23) de commande de la vitesse détecte une faible vitesse prédéterminée,
la commutation dudit troisième commutateur (22) étant exécutée dans une gamme de vitesses inférieures à la commutation desdits seconds commutateurs (17, 18) et à la commutation desdits premiers commutateurs (5A, 5B).

3. Dispositif selon la revendication 1 ou 2, caractérisé en ce que ledit détecteur de position (3), lesdits circuits (6, 7) de formation d'impulsions MID, lesdits premiers commutateurs (5A, 5B) et ledit détecteur de fréquence (50) sont contenus dans un bloc (1) situé côté codage, tandis que lesdits convertisseurs numérique/analogique (12, 13), lesdits circuits de mise en forme d'impulsions (15, 16), lesdits détecteurs de position approximative et précise (19, 14), lesdits circuits (61, 67) de production d'impulsions originelles, lesdits seconds commutateurs (17, 18), lesdits premier et second détecteurs de position/vitesse (20, 21), ledit troisième commutateur (22) et ledit dispositif (23) de commande de la vitesse sont contenus dans un bloc (2) situé côté commande,
que lesdits signaux analogiques délivrés par ledit détecteur de position (3) sont convertis en des signaux numériques et transmis au bloc (2) situé côté commande, par ledit bloc (1) situé côté codage, et
que ledit bloc (2) situé côté commande reçoit et reconvertit lesdits signaux numériques en signaux analogiques pour détecter une position et/ou une vitesse dudit corps mobile ou rotatif.

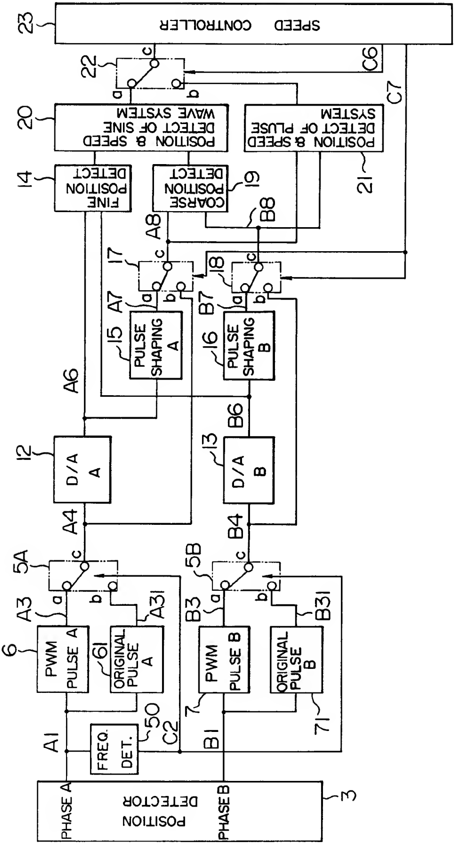
4. Dispositif selon la revendication 3, caractérisé en ce que ledit bloc (1) situé côté codage et ledit bloc (2) situé côté commande sont couplés électriquement entre eux par des moyens d'isolation galvanique (10).

5. Dispositif selon la revendication 4, caractérisé en ce que lesdits moyens d'isolation galvanique (10) sont constitués par un optocoupleur ou un transformateur d'impulsions.

F I G. 1


SPEED CONTROLLER
23
POSITION & SPEED DETECTOR OF SINE WAVE SYSTEM
20
FINE POSITION DETECT
14
COARSE POSITION DETECT
19
A8
B8
PULSE SHAPING A
15
PULSE SHAPING B
16
A6
B6
D / A A
12
D / A B
13
A4
B4
PWM PULSE A
6
PWM PULSE B
7
A1
B1
PHASE A
PHASE B
POSITION DETECTOR
3

F I G. 2


SPEED CONTROLLER
23
22
C6
C7
POSITION & SPEED DETECT OF SINE WAVE SYSTEM
20
POSITION & SPEED DETECT OF PLUSE SYSTEM
21
FINE POSITION DETECT
14
COARSE POSITION DETECT
19
A8
B8
17
18
A7
B7
PULSE SHAPING A
15
PULSE SHAPING B
16
A6
B6
D/A A
12
D/A B
13
A4
B4
5A
5B
A3
A31
B3
B31
PWM PULSE A
6
ORIGINAL PULSE A
61
PWM PULSE B
7
ORIGINAL PULSE B
71
FREQ. DET.
50
C2
A1
B1
POSITION DETECTOR
PHASE A
PHASE B
3

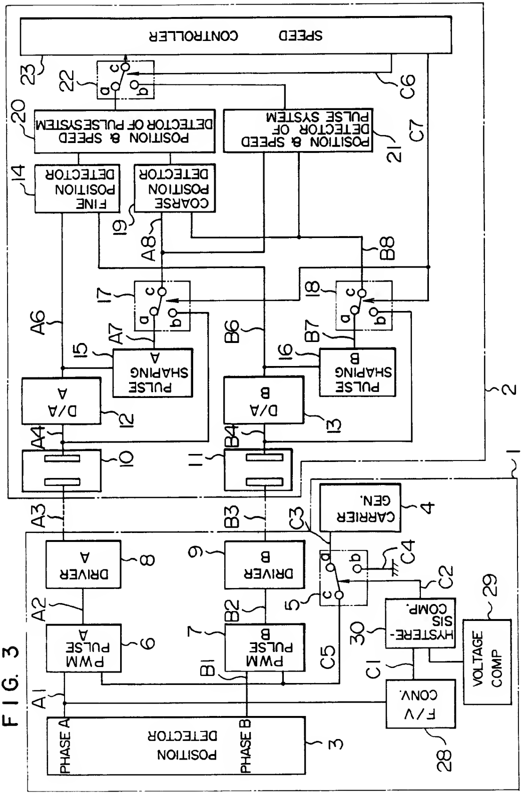
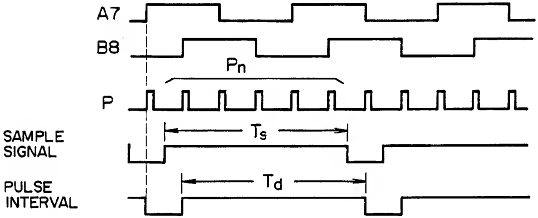

SPEED CONTROLLER
POSITION & SPEED DETECTOR OF PULSE SYSTEM
POSITION & SPEED DETECTOR OF PULSE SYSTEM
FINE POSITION DETECTOR
COARSE POSITION DETECTOR
PULSE SHAPING A
PULSE SHAPING B
D/A A
D/A B
CARRIER GEN.
DRIVER A
DRIVER B
PWM PULSE A
PWM PULSE B
HYSTERE-SIS COMP.
VOLTAGE COMP
F/V CONV.
POSITION DETECTOR
PHASE A
PHASE B
A1
A2
A3
A4
A6
A7
A8
B1
B2
B3
B4
B6
B7
B8
C1
C2
C3
C4
C5
C6
C7
a
b
c
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
28
29
30

FIG. 3

FIG. 4 (PRIOR ART)



F I G. 5

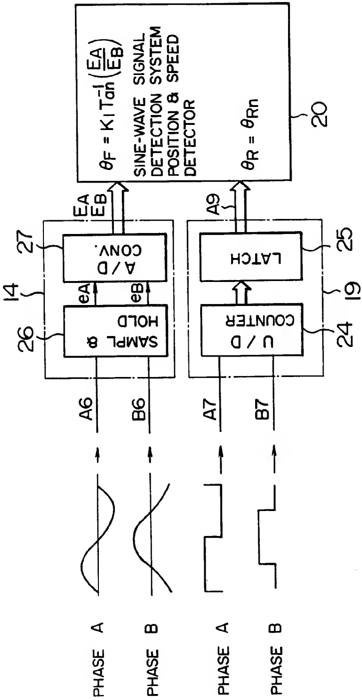
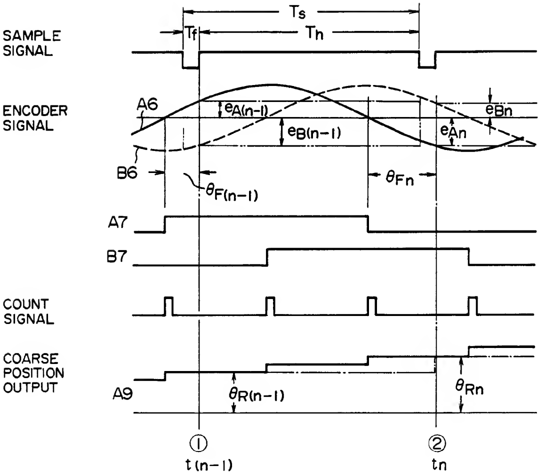

PHASE A
PHASE B
PHASE A
PHASE B
A6
B6
A7
B7
SAMPL & HOLD
26
eA
eB
A/D CONV.
27
14
EA
EB
U/D COUNTER
24
LATCH
25
19
A9
$\theta_F = K_1 Tan^{-1}\left(\frac{EA}{EB}\right)$
SINE-WAVE SIGNAL DETECTION SYSTEM POSITION & SPEED DETECTOR
$\theta_R = \theta_{Rn}$
20

FIG. 6


Ts
Tf
Th
SAMPLE SIGNAL
ENCODER SIGNAL
A6
B6
eA(n-1)
eB(n-1)
eBn
eAn
θF(n-1)
θFn
A7
B7
COUNT SIGNAL
COARSE POSITION OUTPUT
A9
θR(n-1)
θRn
①
t(n-1)
②
tn

F I G. 7

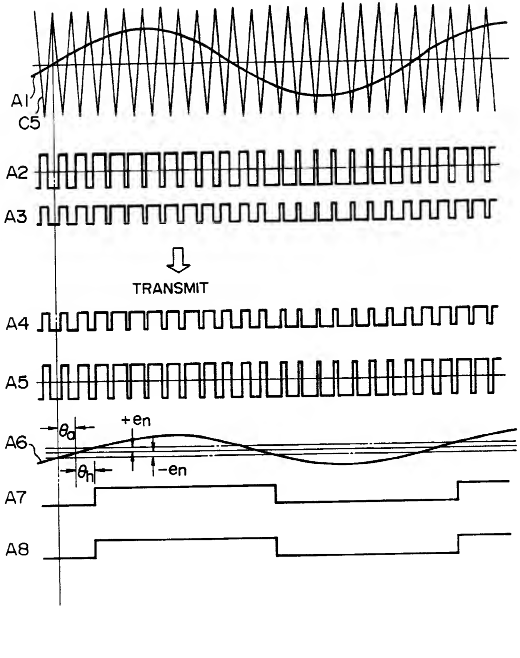


FIG. 8

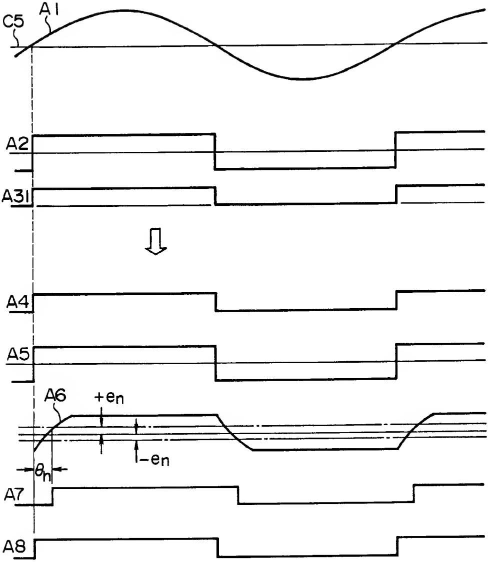
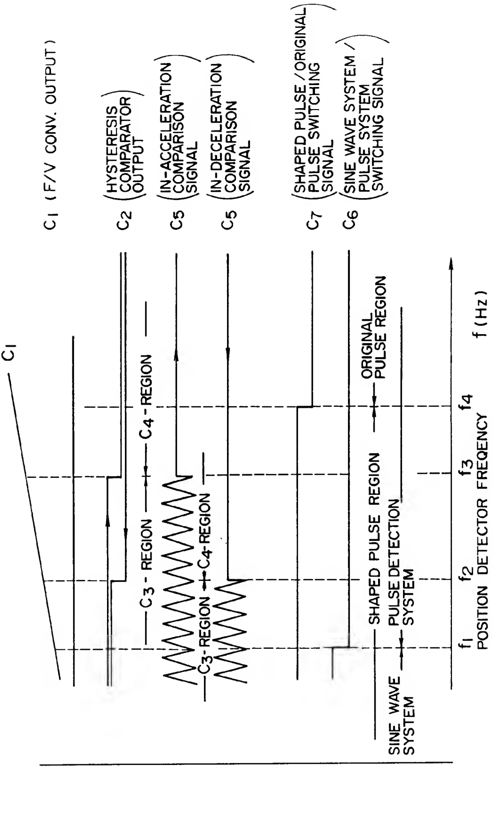
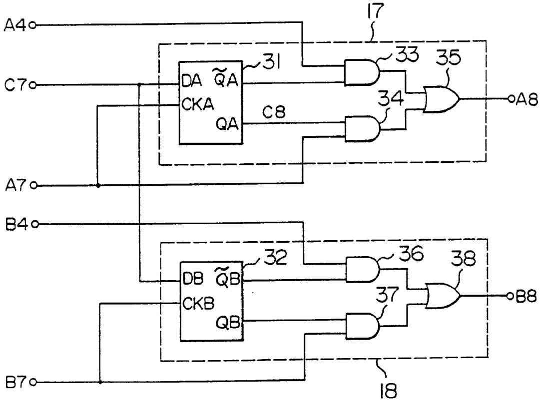


FIG. 9


C1
C1 (F/V CONV. OUTPUT)
C2 (HYSTERESIS COMPARATOR OUTPUT)
C5 (IN-ACCELERATION COMPARISON SIGNAL)
C5 (IN-DECELERATION COMPARISON SIGNAL)
C7 (SHAPED PULSE / ORIGINAL PULSE SWITCHING SIGNAL)
C6 (SINE WAVE SYSTEM / PULSE SYSTEM SWITCHING SIGNAL)
C3 - REGION
C4 - REGION
C3-REGION
C4-REGION
SINE WAVE SYSTEM
PULSE DETECTION SYSTEM
SHAPED PULSE REGION
ORIGINAL PULSE REGION
f1
f2
f3
f4
f (Hz)
POSITION DETECTOR FREQENCY

F I G. 10


A4
C7
A7
B4
B7
17
31
DA
$\tilde{Q}$A
CKA
QA
C8
33
35
34
A8
32
DB
$\tilde{Q}$B
CKB
QB
36
38
37
B8
18

F I G. 11

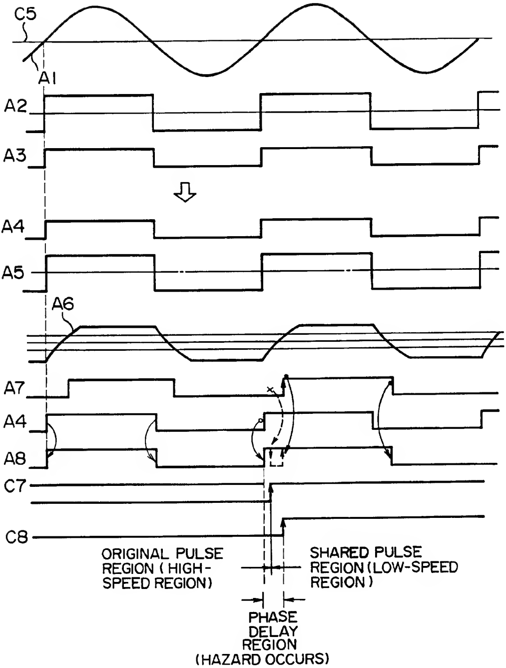
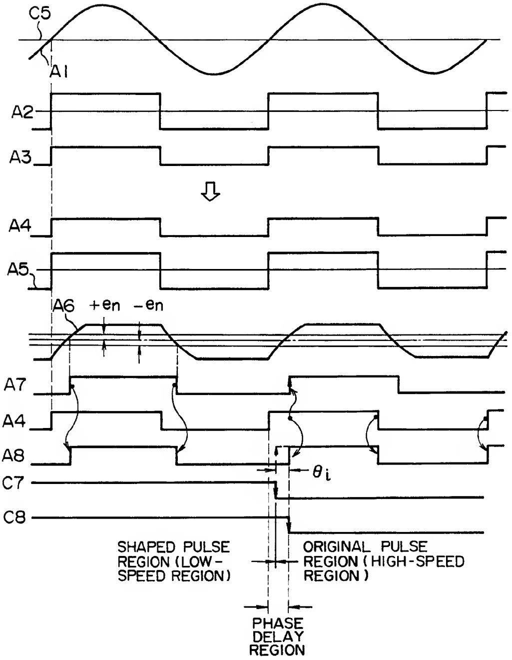
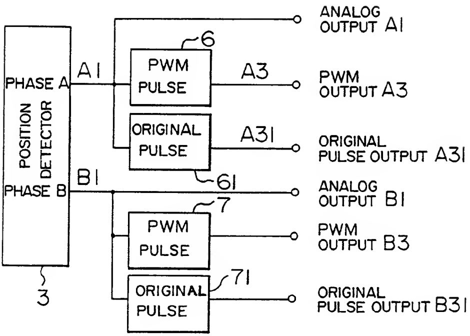

C5
A1
A2
A3
A4
A5
A6
A7
A4
A8
C7
C8
ORIGINAL PULSE REGION (HIGH-SPEED REGION)
SHARED PULSE REGION (LOW-SPEED REGION)
PHASE DELAY REGION (HAZARD OCCURS)

FIG. 12


C5
A1
A2
A3
A4
A5
A6
+en
-en
A7
A4
A8
θ_i
C7
C8
SHAPED PULSE REGION (LOW-SPEED REGION)
ORIGINAL PULSE REGION (HIGH-SPEED REGION)
PHASE DELAY REGION

F I G. 13


POSITION DETECTOR
PHASE A
PHASE B
3
A1
B1
PWM PULSE
6
ORIGINAL PULSE
61
PWM PULSE
7
ORIGINAL PULSE
71
A3
A31
ANALOG OUTPUT A1
PWM OUTPUT A3
ORIGINAL PULSE OUTPUT A31
ANALOG OUTPUT B1
PWM OUTPUT B3
ORIGINAL PULSE OUTPUT B31